technische universität dortmund

mpii

NVIDIA

ARCS 2008

# GPGPU Application Showcase

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**ARCS 2008 - Architecture of Computing Systems**
**GPGPU and CUDA Tutorials**
**Dresden, Germany, February 25 2008**

# Overview

- Linear algebra
- Molecular dynamics, protein folding
- Finance modeling
- SETI, Signal processing (FFT)
- Raytracing
- Physics simulation (fluid, cloth, collision)
- Sequence matching (Hidden Markov Models)
- Speech / Image recognition
- Databases
- Sorting and searching
- Medical imaging (segmentation, processing)
- Large scale numerical simulations
- Astrophysics
- Lattice QCD, theoretical physics

- And many many many more, see gpgpu.org for details

- We present 'selected examples'. Many alternative implementations exist, see gpgpu.org.

# Sorting

- **GPUSORT**
  - Naga Govindaraju, Dinesh Manocha, Nikuni Raghuvanshi, David Tuft
  - http://www.gamma.cs.unc.edu/GPUSORT
  - GPU sorting library available for public download
  - Outperforms hand-optimised SSE/MT CPU code
  - Techniques: Bitonic merge sort, sorting networks

- **GPUTeraSort**
  - Naga Govindaraju, Jim Gray, Ritesh Kumar, Dinesh Manocha
  - ACM SIGMOD 2006 paper
  - Billion-record databases, hundreds of GBytes, CPU performs IO and resource management, GPU sorts
  - 2006 Indy PennySort winner (fastest price/performance)

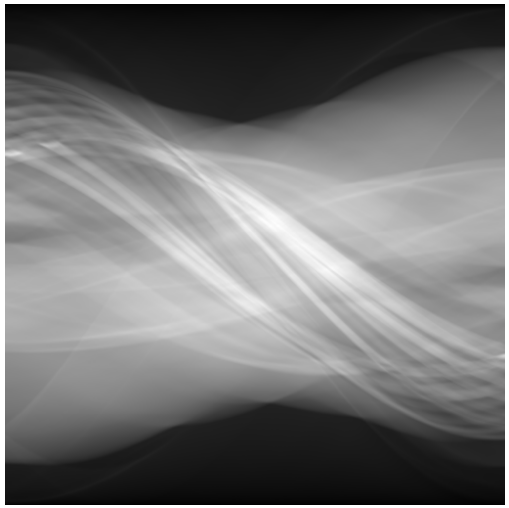
# FFT Libraries

- **GPU FFT**
  - Daniel Reiter Horn, Stanford
  - http://sourceforge.net/projects/gpufft
- **GPUFFTW**
  - Naga Govindaraju, Scott Larsen, Jim Gray and Dinesh Manocha
  - ACM Supercomputing 2006
  - http://gamma.cs.unc.edu/GPUFFTW
  - Not related to FFTW
- **Other libraries**
  - CUDA FFT library (NVIDIA)
  - Brook/brook+ FFT applications
  - ACML FFT library (AMD)

# FFT Applications

## Filtered Back-Projection

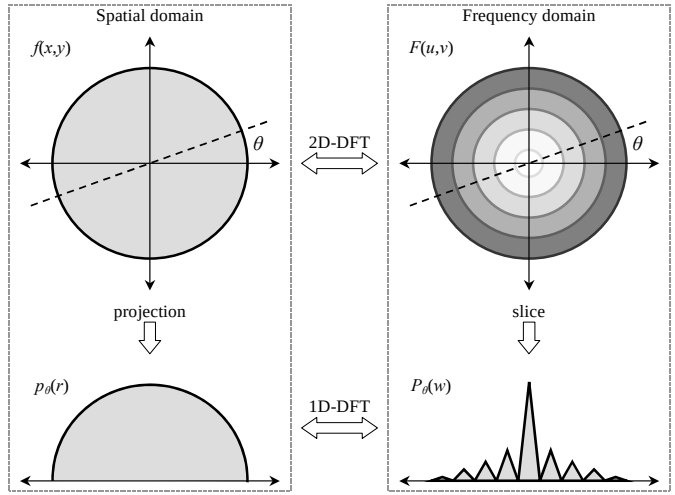
- Create volume from projections
  - Blending of “FFT-filtered” projections
  - Visualization of intermediate results!
- Faster by an order of magnitude!
  - 4.5 min (CPU) vs. 24 sec (GPU)



Movie ...

## Fourier Volume Rendering

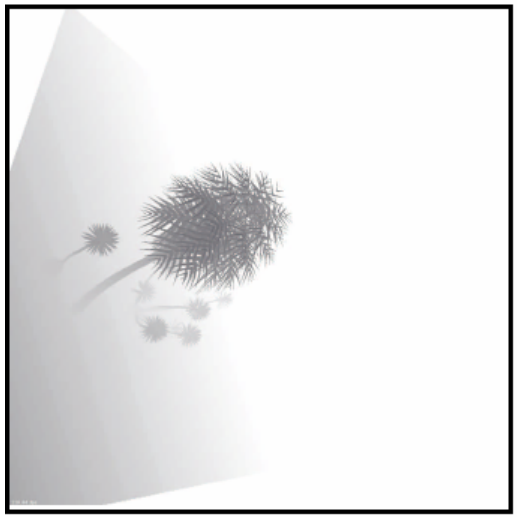
- Inverse Filtered Back-Projection
  - Slice in frequency = Projection
  - Needs high-quality interpolation
- $512^3$ rendered in >25 frames/sec
  - But needs slightly more space!



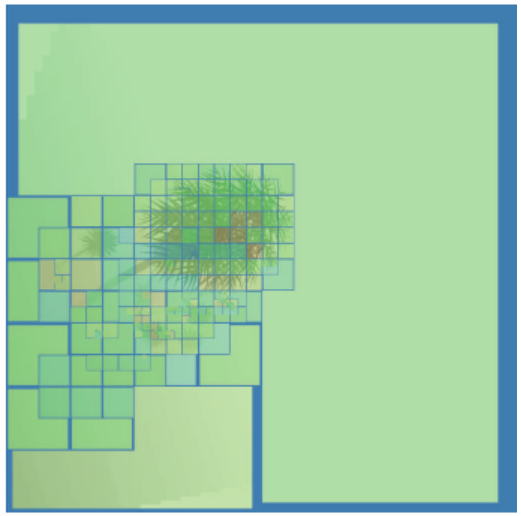

[Thomas Jansen et al., VMV 2004]

# Glift : Generic, Efficient, Random-Access GPU Data Structures





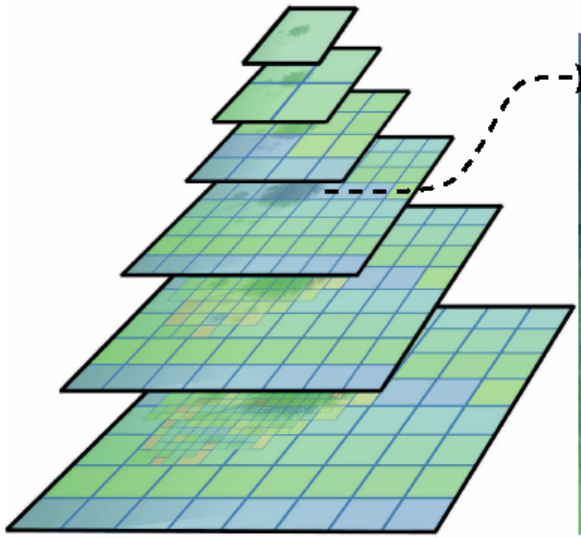
A) Virtual Domain



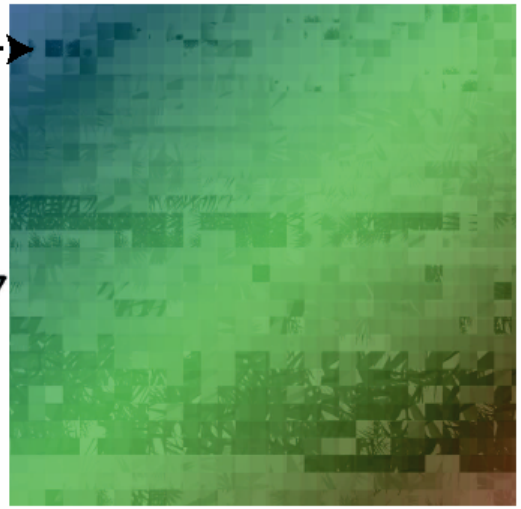
B) Adaptive Tiling

[Aaron Lefohn et al., ACM TOG, 2006]

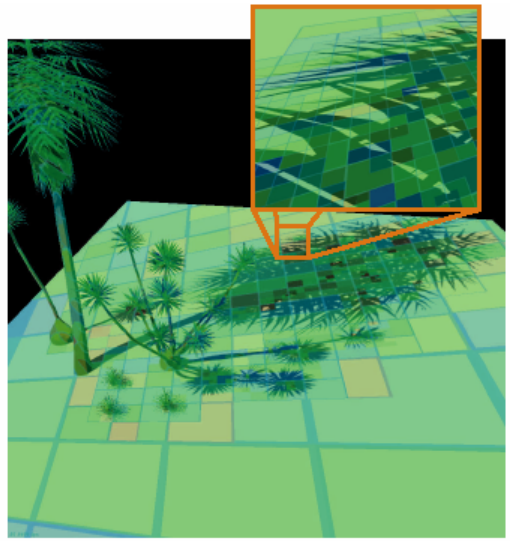
STL-like abstraction of data containers from algorithms for GPUs



C) Page Table



D) Physical Memory

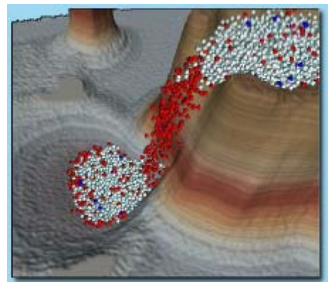


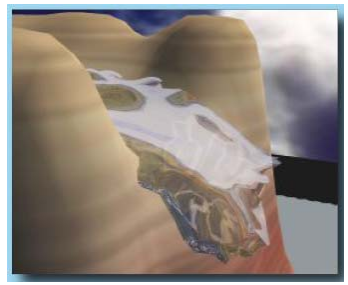
E) Adaptive Shadow Map Rendering

Movie ...

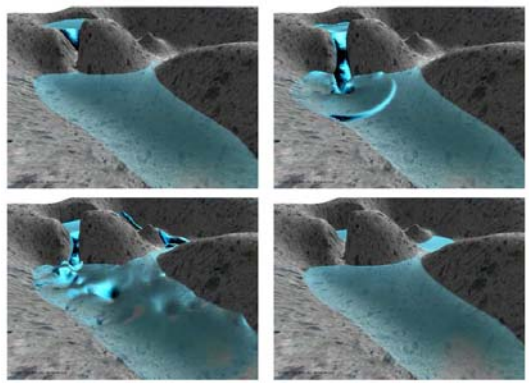
# Linear Algebra, Numerical Simulation

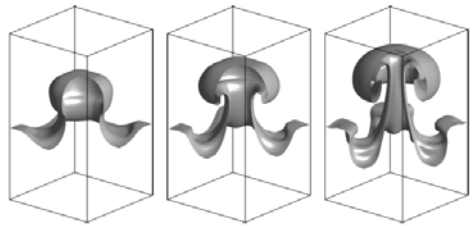
- **Pioneering work on**
  - Dense and sparse LA
  - Conjugate Gradients and Multigrid solvers
  - BLAS levels 1, 2, 3 (BLAS 3 efficiently is relatively new)
  - LU decomposition (LINPACK)





- **Simulation of fluid flow**
  - Navier-Stokes
  - Smoothed particle hydrodynamics
  - Lattice Boltzmann
  - Euler equations

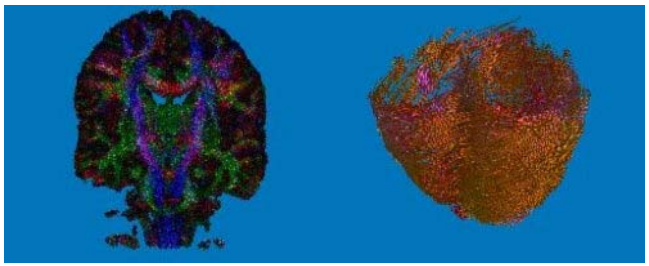


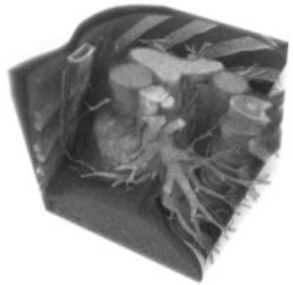


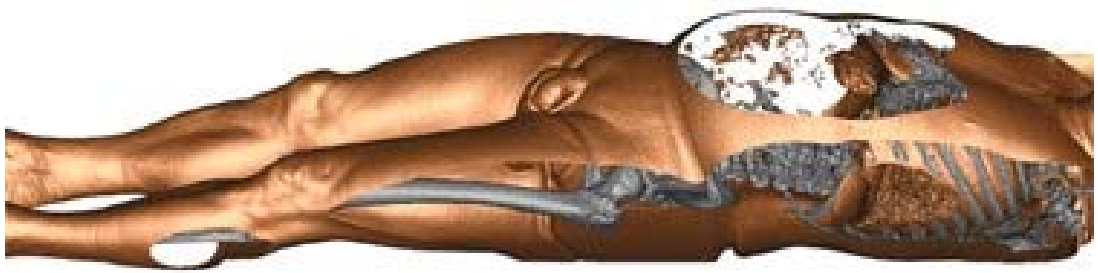
Images courtesy of Jens Krüger, Peter Kipfer, Trond Runar Hagen

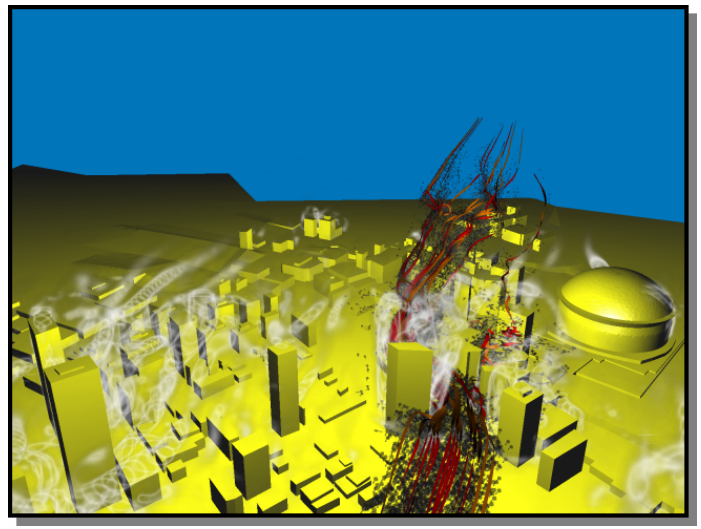
# Scientific visualisation

- **Jens Krüger, Rüdiger Westermann et al., TU Munich**
  - http://wwwcg.in.tum.de/Research/Projects/SciVis
  - Winner of the IEEE Visualisation Contest 2005,2006
  - Flow Visualisation
  - Iso-surface extraction and rendering
  - Tensor visualisation
  - Volume visualisation









# Folding @ Home

- **Perf stats last night**
  - 227,219 active CPUs delivering 246 TFLOP/s
  - 509 active GPUs delivering 30 TFLOP/s
  - 31,663 PS3s delivering 785 TFLOP/s

- **GPU client is fast**
  - 59 GFLOP/s per GPU client
  - 25 GFLOP/s per PS3 client
  - 1 GFLOP/s per CPU client